A New Virtual-Reality Training Module for Laparoscopic Surgical Skills and Equipment Handling: Can Multitasking be Trained? A Randomized Controlled Trial

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OBJECTIVE: During laparoscopic surgery distractions often occur and multitasking between surgery and other tasks, such as technical equipment handling, is a necessary competence. In psychological research, reduction of adverse effects of distraction is demonstrated when specifically multitasking is trained. The aim of this study was to examine whether multitasking and more specifically task-switching can be trained in a virtual-reality (VR) laparoscopic skills simulator.

DESIGN: After randomization, the control group trained separately with an insufflator simulation module and a laparoscopic skills exercise module on a VR simulator. In the intervention group, insufflator module and VR skills exercises were combined to develop a new integrated training in which multitasking was a required competence. At random moments, problems with the insufflator appeared and forced the trainee to multitask. During several repetitions of a different multitask VR skills exercise as posttest, performance parameters (laparoscopy time, insufflator time, and errors) were measured and compared between both the groups as well with a pretest exercise to establish the learning effect. A face-validity questionnaire was filled afterward.

SETTING: University Medical Centre Utrecht, The Netherlands.

PARTICIPANTS: Medical and PhD students ($n = 42$) from University Medical Centre Utrecht, without previous experience in laparoscopic simulation, were randomly assigned to either intervention ($n = 21$) or control group ($n = 21$).

RESULTS: All participants performed better in the posttest exercises without distraction of the insufflator compared with the exercises in which multitasking was necessary to solve the insufflator problems. After training, the intervention group was significantly quicker in solving the insufflator problems (mean = 1.60 Log(s) vs 1.70 Log(s), $p = 0.02$). No significant differences between both the groups were seen in laparoscopy time and errors.

CONCLUSION: Multitasking has negative effects on the laparoscopic performance. This study suggests an additional learning effect of training multitasking in VR laparoscopy simulation, because the trainees are able to handle a secondary task (solving insufflator problems) quicker. These results may aid the development of laparoscopy VR training programs in approximating real-life laparoscopic surgery. (J Surg 72:184-191. © 2014 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: virtual reality, simulation, multitasking, distraction, laparoscopy, education

COMPETENCIES: Practise-Based Learning and Improvement, Medical Knowledge

INTRODUCTION

Laparoscopic surgery has obtained a major position within surgical specialties.[1] For this type of surgery, additional psychomotor and hand-eye coordination skills are needed. To learn these skills, effective preclinical simulation training

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has been developed.[2,3] Preclinical simulation training includes video/box training, virtual-reality (VR) training, and training on porcine models.[4] VR training is effective to improve the performance level and reduce operation time.[5] Advantages of VR training are a safe, controlled environment to master the basic skills; objective automatic scoring of performance; and the possibility of unlimited repetitions of training situations.[5-10]

As there is less time for residents to learn the laparoscopic procedures, optimizing the efficacy of laparoscopic training is important.[11] Another incentive for this kind of research is the public expectation of safer health care systems and reduction of medical errors.[12] Among surgical medical errors, the technical errors, or execution failures, are the most common.[13] These include a high incidence of problems with handling laparoscopic technical equipment.[13,14] An example is the laparoscopic insufflator that regulates a good view in the abdominal cavity by inflating the abdomen. During surgery, problems with the insufflator can worsen laparoscopic performance as the surgeon has to switch attention from the actual operation to the insufflator.[14] When an individual needs to concurrently attend to more than 1 task, this is known as multitasking in medical literature.[15,16] Multitasking is a necessary competence in the operation room, that experienced surgeons master better then novices.[17] It is well known that distraction and multitasking have negative effects on the performance of laparoscopic tasks.[18,19] One study proved that trainees who were instructed to gaze at the target object instead of following the movements of their laparoscopic instruments performed better when they got distracted.[17,20] However, to our best knowledge this seems to be the only study with evidence that a special form of multitasking (e.g., task-switching) can be trained in a laparoscopic VR simulation environment. In "task-switching" 2 or more tasks are performed in a rapid succession. It is proven in (neuro)psychology that sequentially switching between tasks worsens the performance compared with separately executing the same tasks.[21] It is also known that training can greatly reduce these "costs" of multitasking.[19,21-23] We wanted to translate this knowledge to VR laparoscopy training. Separately, laparoscopic skills training exercises and a VR training model of a laparoscopic insufflator has been developed and validated previously.[10,24,25] We integrated this insufflator model in the existing VR laparoscopic skills exercises and hereby developed a new VR module for training laparoscopic surgery. In this way, the trainee is confronted with insufflator problems that distracts from the actual laparoscopic skills exercise. Strictly, this is called "task-switching" (a special form of multitasking), because the surgeon switches between the laparoscopy task and solving the insufflator problem. In this study, the more commonly known umbrella term "multitasking" is used.

The objectives of this randomized controlled trial are as follows:

- Firstly, to investigate whether multitasking can be trained in a VR simulation setting (e.g., participants specifically trained with integrated insufflator problems during VR laparoscopy skills exercises might perform better in multitasking exercises in comparison with those who trained with insufflator and laparoscopy skills exercises separately).
- Secondly, to confirm the finding that multitasking has a negative effect on the performance of VR laparoscopic skills exercises.

METHODS

Participants

MD and PhD students of the departments of surgery and gynecology from the Medical University of Utrecht were recruited for voluntary participation ($n = 42$). A questionnaire was completed before the training session to collect demographic data. None of the participants had experience on the VR simulator used in this study. Participants were informed about the objectives of the study. All participants gave written consent before the start of the study.

Materials and Techniques

The SIMENDO VR simulator (Simendo B.V., Rotterdam, The Netherlands) for training laparoscopic skills was used. This simulator consists of a software interface and 2 hardware instruments connected with a Universal Serial Bus plug to a personal computer (Fig. S1). The PC contained an Intel core i7 Duo processor FX500 (2.80 GHz, 4.00 GB RAM), with graphical card NVIDIA Quadro FX 580, 1680 × 1050 LCD monitor, and Microsoft Windows 7 software.

The simulation software consisted of laparoscopic skills training exercises and the insufflator module. For skills training, 4 previously validated exercises were used.[10] The insufflator module is a VR simulation of a laparoscopic insufflator in which its function can be learned and problem scenarios are simulated.[26] Scenarios included problems with intra-abdominal pressure built-up, tube obstruction, and gas supply. For this study, we developed a multimodal environment in which the insufflator module was integrated in the laparoscopic skills exercises (Fig. S2). During the insufflator scenarios, the time of laparoscopy was paused and started again after the insufflator problem was solved successfully.

Design

This study is a prospective randomized trial. Randomization into an intervention group ($n = 21$) and a control group ($n = 21$) was applied with stratification for gender. The training program for both groups is shown in detail in the Figure. At the start, all the participants received the same